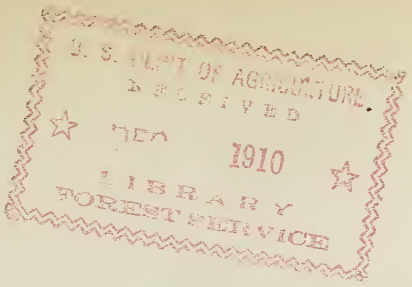


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# HANDLING WHEAT FROM FIELD TO MILL.

BY

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## BUREAU OF PLANT INDUSTRY.

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# HANDLING WHEAT FROM FIELD TO MILL.

## INTRODUCTION.

In the campaigns being waged for good farming much is heard concerning the maintenance of soil fertility, the conservation of moisture, proper crop rotation, good seed, and good seed bed, pure varieties, and many other vital topics. These are all important matters, but full benefit is not derived from the practice of these good methods if the crop of wheat is not properly cared for after maturity until it reaches the mill.

Increasing the average yield per acre one or two bushels means a great deal when it is considered that for the last ten years an average of 46,678,000 acres of wheat has been grown in the United States. It would also mean a great deal if by better methods of caring for the crop after maturity wheat could be placed upon the market that would average one grade better than the present product. The average yearly production of wheat for the last ten years has been 659,509,000 bushels. If the grade of this quantity were raised one point, or one grade, it would mean an increase in price of from 1½ to 2 cents a bushel, which would give an increased value amounting to from 10 to 13 million dollars.

## METHODS OF HARVESTING WHEAT.

There are various methods of harvesting and caring for the wheat crop, depending upon the section of the country in which it is grown. In the Eastern States the wheat is cut with a self-binder, and most of it is either stacked or stored in the mows of large barns. West of the Mississippi River, in the Great Plains area, both self-binders and headers are used, and only a comparatively small portion of the wheat cut with the binder is stacked, the larger portion being thrashed direct from the shock.

The header is used most in the western portions of the Dakotas, Nebraska, and Kansas, but the relative quantity cut in this way depends much upon the season. It is usual to start with the binder, and if the season is such that the grain ripens rather slowly, the header

is used but little. On the other hand, if the ripening process goes on rapidly and the weather remains dry, headers are used, because more acres can be harvested in the same length of time. In the latter case the grain is stacked as soon as it is cut.

On the Pacific coast and in the extreme Northwest the combined harvester and thrasher is used quite generally. By this method the grain is cut, thrashed, and sacked in one operation. Dry weather nearly always prevails throughout this section during the harvest season, and little injury results from exposure to weather.

Each of these methods has its advantages and its disadvantages, but many of the disadvantages grow out of the abuse of the method.

## EFFECT OF METHODS OF HARVESTING ON QUALITY AND MARKET VALUE.

Owing to the fact that such a large proportion of the wheat of the United States is produced in the area lying between the Mississippi River and the Rocky Mountains, commonly referred to as the Great Plains area, a very large percentage of the total crop is, by reason of the methods of handling, exposed for a considerable time to weather conditions which cause it to deteriorate.

Statistics for the years 1908 and 1909 show that more than 44.3 per cent of the total yearly acreage of winter wheat, producing a yearly average of more than 192 million bushels, has been grown within this section. During the same period 94.7 per cent of the total yearly acreage of spring wheat, with a yearly average of 228 million bushels, has also been produced within this Great Plains area.

These figures show also that a yearly average of more than 29 million acres of wheat is grown in a region where a very large proportion of it is allowed to stand in the shock from three to six weeks, or even longer, and often there is a heavy rainfall on it during this time. The man who will take proper precautions with soil and seed is also more likely to take proper care of his crop after maturity. It can not be denied that many a farmer's crop of wheat is allowed to be practically ruined for flour-making purposes after a very good quality of grain has matured in the field. Sometimes this is unavoidable, but more often it is the result of carelessness. Many times it happens because the farmer does not realize that these unfavorable weather conditions materially injure the quality of his wheat. Much of the wheat in Texas, Oklahoma, Kansas, Nebraska, Minnesota, and the Dakotas is not even carefully shocked, the shocks being set up carelessly and not protected at all by cap bundles. This is especially true of the larger fields in the western portions of these States.

This exposure to the effect of alternating rain and hot sun causes the kernels to swell and the branny coats to loosen, destroying the nat-

ural color or " bloom " and giving them what is termed a " bleached " appearance. Even when well shocked and protected by a cap bundle, continued exposure brings on a change in the outer bundles, which are only poorly protected at best, and after a shock has stood a month, or even less, it is found that as a result of this weather damage samples of wheat taken from the outer portions of the shock are at least a grade poorer than those taken from the inner part of the same shock. In thrashing, this poor wheat is mixed with the good and the grade of the whole is lowered. Such exposure and the resulting change in appearance have a direct and immediate effect upon the market value of the grain. The grade that is given to wheat upon the terminal markets depends to-day almost wholly upon its appearance, condition, and test weight per measured bushel. When the natural color or " bloom " of the kernel has been destroyed by rain and sun while standing in the shock and the increase in moisture content has caused a corresponding decrease in the test weight per bushel, the grade given is lower than it would be if this same wheat were marketed in good condition without deterioration resulting from exposure to the weather. It is common knowledge among farmers that wheat standing in the shock may readily lose a pound per bushel in test weight on being exposed to a heavy shower. This is especially true where the wheat has been carelessly shocked and is not protected by cap bundles.

### RELATION OF MOISTURE CONTENT TO TEST WEIGHT.

Preliminary tests of the relation between moisture content and test weight per bushel in wheat have been made in several of the Grain Standardization laboratories of the Bureau of Plant Industry, and the results of these tests indicate that while the rate of increase in moisture content is not accompanied by a constant rate of decrease in test weight per bushel, nevertheless a close relation exists between the two factors. Furthermore, the data secured in these preliminary tests support the belief that when once the moisture content has been materially increased and the test weight per bushel correspondingly lowered through that cause there is not a corresponding reverse action; or, in other words, although wheat that has absorbed a high percentage of moisture may be again dried out to approximately its former moisture content, it regains comparatively little of the test weight lost. This applies especially to wheat when thrashed from the shock.

### EFFECT ON SOUNDNESS OF EXPOSURE TO WEATHER.

In addition to causing the bleached appearance and lowering the test weight, the exposure of wheat to rain and sun while standing in the shock causes many of the kernels to sprout, and sprouted wheat

will not produce good, sound flour. Furthermore, the indications are that this excess moisture acquired by exposure in the field after harvest continues to be a source of injury to the quality until the wheat is dried either artificially or by natural means.

### "SWEAT" IN WHEAT.

Millers, as well as operators of country and terminal elevators, prefer wheat that has gone through the "sweat." The millers invariably hold that sweating in the stack improves weathered grain and is much to be desired. Comparatively little is known as to what the process commonly referred to as "sweat of wheat" consists of. Very little information concerning it can be gleaned from scientific literature. The following has been advanced as a possible explanation of the change that takes place during the process. It is known that even after wheat is cut the straw contains sufficient plant food to keep the kernels in a growing condition for some time, and a chemical or enzymic action within the plant by means of which this nutriment is transferred to the grain and stored as starch may continue for a considerable period. When wheat has been thrashed before going through the sweat, it is probable that a rearrangement of the chemical constituents of the kernels still takes place, and this will account for the sweating of shock-thrashed grain in the bin.

As chemical action is generally accompanied by the evolution of heat, this may account for the heat usually generated during the sweating process. The amount of heat generated appears to be influenced by the percentage of moisture present. Grain that has been sufficiently ripened and is also very dry will give little evidence through change in temperature that it is going through the sweating process. On the other hand, wheat cut in the hard-dough stage, or containing considerable moisture, goes into the sweat much more quickly when stacked; the straw becomes very tough and a great deal of heat is evolved. Care should be exercised not to stack wheat of this character before it is allowed to cure out in the shock for a few days; otherwise sufficient heat may be evolved, even in the stack, to injure the grain, in which case "stack-burnt" wheat will result.

Cutting the grain seems to act as a sort of check upon this biological action, and it appears to remain in a dormant state until the assembling of the grain in large bulk brings on a condition favorable to activity. When the grain is stacked the straw permits to a limited extent the circulation of air through the stack, and this circulation affords a means of conducting away considerable of the heat generated in stacked grain.

### HEAT-DAMAGED OR "BIN-BURNT" WHEAT.

If wheat with a rather high moisture content is placed, before going through the sweat, in a large bulk in a bin there is very little chance

for circulation of air, and any heat generated by biological action is retained in the grain until finally the temperature becomes so high as to cause other chemical changes within the kernels; the result is what is commonly known to the grain trade as heat-damaged or "bin-burnt" wheat. This injury may extend simply into the branny coats and produce slightly heat-damaged or "bran-burnt" wheat, or it may extend throughout the endosperm and produce badly heat-damaged or "bin-burnt" kernels. Wheat in this last condition is practically unfit for flour-making purposes.

There is little evidence as to whether or not this change or sweat which takes place in the bin is identical with that which takes place in the stack. It at least appears to have much the same effect on the milling and baking qualities, provided the wheat is not allowed to heat enough to become injured or "bin-burnt."

## EFFECT OF SWEATING IN STACK ON APPEARANCE AND TEST WEIGHT.

In order to make a preliminary test regarding the validity of the practically unanimous opinion among farmers and millers that wheat which had been bleached in the shock was improved in color and test weight per bushel upon being stacked and allowed to go through the sweat in the stack, and also to discover what effect this sweating process in the stack would have upon the market grade and the milling and baking value of the wheat, arrangements were made during the harvest of 1909 to secure from a 12-acre field of Fife wheat near Fargo, N. Dak., a load of bundles taken from the shock after they had been exposed to at least two heavy rains. This load was thrashed and the wheat stored in a small elevator bin. The remainder of the field was stacked and after standing in the stack six weeks was thrashed. Fifty bushels of the stacked wheat, taken from the same portion of the field as the before-mentioned load of shocked bundles, was placed in another small bin in the same elevator for comparison with the shock-thrashed wheat.

The shock-thrashed sample as it came direct from the thrashing machine contained 14.8 per cent of moisture, and the test weight per bushel was 55.5 pounds. The grain felt damp and tough and would scarcely have been considered in safe condition for shipment to market.

## MILLING TESTS OF SHOCK-THRASHED AND STACK-THRASHED WHEATS.

Table I shows in detail the results of the experimental milling tests with the shock-thrashed and stack-thrashed wheats. Four days after thrashing, on August 31, a sample of about 2 bushels of the shock-thrashed wheat (lot No. 398) was milled in the experimental mill at

the agricultural college, Fargo, N. Dak. The loss in milling on this sample so far exceeded the average loss of 2.12 per cent on like samples of hard spring wheat milled at Fargo that some explanation is necessary. This excessive loss was probably due to the high moisture content of the wheat and also to the fact that the mill had not been used for some days, and although some wheat was ground in order to "fill the mill" and products were received from all the spouts before sample No. 398 was started, still the milling loss was far in excess of the average for hard spring wheat.

A second sample of the shock-thrashed wheat (No. 398 A) was milled on September 17, after the wheat had remained in the bin eighteen days. The wheat milled tough, and it was very difficult to clean off the bran. The wheat appeared to be going through a sort of sweat, and it felt more tough and clammy than when first placed in the bin.

After the lot of shock-thrashed wheat (No. 398) had been stored in the elevator bin for sixty days, 50 bushels of the stack-thrashed lot (No. 460) were received at the mill. The stack-thrashed wheat contained 13.2 per cent of moisture and tested 59 pounds per measured bushel, as against 14.8 per cent of moisture and 55.5 pounds per bushel in the shock-thrashed wheat at the time of thrashing.

On October 26 a third sample of the shock-thrashed wheat (No. 398 B) was milled, and a sample of the stack-thrashed wheat (lot No. 460) was likewise milled on the same day. By comparing the data in Table I it will be noted that in the milling of the stack-thrashed wheat (sample No. 460) there was less loss in cleaning the wheat and less loss in milling (except sample No. 398 B) and that there was less bran, more "low grade" and shorts, and more straight flour produced than was the case with the other three samples milled.

No change in the temperature of the shock-thrashed wheat had taken place during storage except the slight variation apparently due to changes in the outside air temperature.

TABLE I.—*Results of experimental milling tests with shock-thrashed wheat compared with the results with stack-thrashed wheat, 1909.*

| Sample No. | Date milled. | Loss in cleaning. | Bran. | Shorts and "low grade." | Straight flour. | Loss in milling. |
|---|---|---|---|---|---|---|
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 398 | August 31 | 1.4 | 12.5 | 15.7 | 60.6 | 11.2 |
| 398 A | September 17 | 1.0 | 15.3 | 15.7 | 63.0 | 6.0 |
| 398 B | October 26 | 1.0 | 13.4 | 18.1 | 68.2 | .3 |
| 460 | do | .6 | 12.1 | 19.0 | 68.4 | .5 |

## BAKING TESTS OF FLOURS MILLED FROM SHOCK-THRASHED AND STACK-THRASHED WHEATS.

Table II shows in detail the results of the experimental baking tests with shock-thrashed and stack-thrashed wheats. As shown in Table I, three different samples of the shock-thrashed wheat and one sample of the stack-thrashed wheat were milled on various dates. Sample No. 398 of the shock-thrashed wheat was milled on August 31 and two bakings were made of the resulting flour, one baking on September 8 and the other on November 4.

A comparison of the baking tests of this sample shows a slightly better water absorption, an increase of 200 c. c. in loaf volume, and a slightly lower grade for color and texture in the second baking. Sample No. 398 A, or the second sample of the shock-thrashed wheat, was milled on September 17 and two bakings were also made from this flour, the first on September 23 and the second on November 4. It will be noted that the results of the first baking test on this sample of flour (No. 398 A) compare very closely with the results of the first baking from sample No. 398, while the results of the second bakings from both samples also compare very closely. On October 26 a third sample of the shock-thrashed wheat (No. 398 B) was milled and a sample of the stack-thrashed wheat (No. 460) was also milled on the same day. On November 4 one sample of each of the flours obtained therefrom was baked.

Comparing the results of the baking test of sample No. 398 B with the first test of sample No. 398, it is found that there was evidently considerable improvement as the wheat "aged," the absorption and loaf volume having both improved considerably. However, it should be noted from the second baking of sample No. 398 that this flour was not as good even after "aging" two months as the freshly milled flour of sample No. 398 B, made from the same wheat after the wheat had "aged" in the bin for the same length of time. Furthermore, none of the three samples milled from the shock-thrashed wheat (samples Nos. 398, 398 A, and 398 B) equaled the sample from the stack-thrashed wheat (sample No. 460).

Work with these samples was continued and a sample from each lot was milled and baked every month. Six different samples were milled and baked from lot No. 398 (shock thrashed) and four samples from lot No. 460 (stack thrashed). The average loaf volume secured from lot No. 398 was 2,610 c. c., while lot No. 460 gave an average loaf volume of 2,700 c. c. The flour made from samples of lot No. 398 had a slight advantage in the color of the bread, but that made from lot No. 460 gave a somewhat higher water absorption.

TABLE II.—*Results of baking tests of flours made from shock-thrashed wheat compared with the results of tests of flours from stack-thrashed wheat, 1909.*[a]

| Sample No. | Baking. | Date baked. | Flour used. | Water absorption. | Weight of loaf. | Volume of loaf. | Color. | Texture. |
|---|---|---|---|---|---|---|---|---|
| | | | *Grams.* | *Per cent.* | *Grams.* | *Cubic cm.* | *Per cent.* | |
| 398 | First | September 8 | 334 | 51.5 | 478 | 2,440 | 102 | Very good. |
| 398 | Second | November 4 | 342 | 52.6 | 476 | 2,640 | 100 | Good. |
| 398 A | First | September 23 | 342 | 51.5 | 480 | 2,500 | 100 | Very good. |
| 398 A | Second | November 4 | 342 | 55.0 | 486 | 2,660 | 100 | Good. |
| 398 B | First | do | 342 | 54.1 | 487 | 2,650 | 100 | Do. |
| 460 | do | do | 338 | 54.7 | 484 | 2,710 | 99 | Do. |

[a] The amount of flour used for each baking is based on 340 grams containing 12 per cent of moisture, or 299.2 grams of dry matter.

## EFFECT OF SWEATING IN THE STACK ON MARKET GRADE.

At the time the stack-thrashed lot (No. 460) was received at the mill, the shock-thrashed lot (No. 398) had improved considerably in condition, the moisture content having decreased from 14.8 per cent to 13.9 per cent. At this time 2-quart samples of each lot were sent to the Minnesota State Grain Inspection Department to be graded. Sample No. 398 from the shock-thrashed wheat was graded No. 2 northern spring wheat, while sample No. 460 from the stack-thrashed lot graded No. 1 northern spring wheat. This circumstance tends to prove that when the wheat goes through the sweat properly in the stack, the color and test weight per bushel may be improved enough to raise it one grade.

## COMPARATIVE COST OF THE TWO METHODS.

The facts mentioned bring up the question of the comparative cost of handling wheat by the two methods. It is very difficult to obtain any definite information as to what the added cost resulting from stacking the grain is, and many wheat growers even deny that it necessarily costs more to stack grain and then thrash from the stack than it does to thrash direct from the shock. Some data regarding this phase of the problem have been compiled from statistics collected in Minnesota.

It is found in Bulletin 73 of the Bureau of Statistics, United States Department of Agriculture, page 50, that the cost of stacking, stack thrashing (labor), and thrashing (cash cost) for a comparatively large acreage in Norman County, Minn., amounted to $1.223 per acre, while the cost of thrashing from the shock on a large farm in northwestern Minnesota amounted to $0.991, a difference of $0.232 per acre in favor of the shock-thrashing method. However, on comparing the other items of expense on the large farm with those on the tract in Norman County it is found that all the other farm operations were carried on much more cheaply on the large farm, and

it is therefore reasonable to assume that stacking could also have been done more cheaply here and that this would lessen the difference in cost of the two methods. At any rate, if by properly stacking the wheat the product could be raised one grade, about 2 cents more per bushel could be secured for it, and allowing an average yield of only 12 bushels per acre this would amount to 24 cents, which fully counterbalances the added cost of stacking in this case.

### ADDED ADVANTAGES DERIVED FROM STACKING WHEAT.

The farmer who properly stacks his wheat secures it against further loss from exposure to weather, while the one who allows his grain to stand in the shock from three to six weeks, waiting for the thrasher, runs the risk of having it deteriorate in quality from No. 1 or No. 2 to No. 4 or even "no grade."

Another gain which may result from properly stacking the wheat is that it will come out of the stack dry and thrash out clean from chaff, thus preventing the loss sustained when thrashing bundles that are damp and tough from rain or dew. With the bundles in this damp condition, considerable wheat remains in the heads or is blown over as "whitecaps" and goes to the straw pile. This is usually a total loss, as much of the straw in the Great Plains area is burned.

Improvement in the quality and condition of the wheat is not the only benefit derived from stacking the crop. In addition to making the crop safe should several heavy rains come after harvest, which would prevent thrashing and cause rapid deterioration, the stack-thrashed grain can be placed in tight bins and kept, or it can be shipped direct to market without imminent danger of heating and spoiling in transit. Also, the shocks are removed from the field, so that plowing may be begun at once, and all good farmers readily agree that such early plowing is productive of good results in the next year's crop.

### SUMMARY.

(1) The average yearly area of wheat in the United States for the last ten years has been 46,578,000 acres. The average yearly production during the same time has been 659,509,000 bushels.

(2) Of the winter-wheat acreage 44.3 per cent and of the spring-wheat acreage 94.7 per cent, or a total of 29,876,000 acres, were grown each year in the Great Plains area, where much of the wheat stood in the shock exposed to unfavorable weather for a considerable time while awaiting the thrasher.

(3) The results of this exposure in the shock to the effects of rain and sun are a bleaching in color, an increase in moisture content, and a decrease in test weight per measured bushel. Continued exposure brings about sprouting and molding in the shock.

(4) Increasing the moisture content causes a decrease in the test weight per bushel, which is not entirely regained when the sample again dries out.

(5) Appearance, condition, and test weight have a direct and immediate effect on the market grade, and therefore on the market value.

(6) "Sweat" in wheat is probably due to biological action which still takes place when the wheat is assembled in bulk after it is cut. When this "sweating" takes place properly in the stack, improvement in color, condition, and test weight results. The milling and baking qualities are also improved by this "sweating" process.

(7) The added cost, if there be any, as a result of stacking may be fully offset by improvement in the quality of the wheat and the higher price resulting therefrom.

(8) Gains other than those resulting from the improvement of the grain itself are also to be secured by stacking the wheat.

Approved:

JAMES WILSON,
*Secretary of Agriculture.*

WASHINGTON, D. C., *July 28, 1910.*

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